Overview of Village Power and Lessons Learned

Dr. Debra Lew

US National Renewable Energy Laboratory

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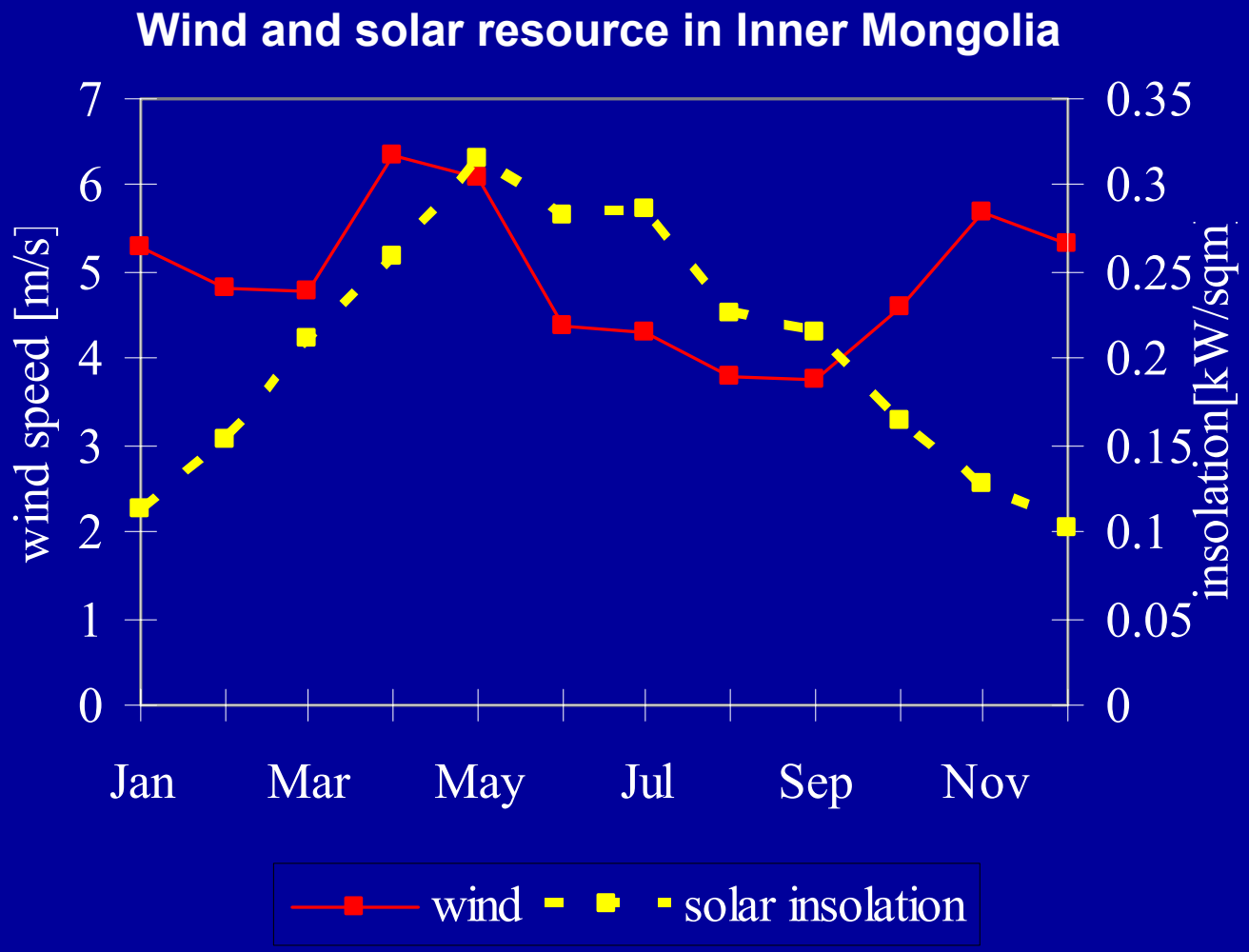
Why AC Hybrid Village Power Systems?

- Higher Power Motor Loads
  - Refrigeration, grain grinding, carpentry
- Higher Renewable Energy Availability
  - Hybrids reduce daily & seasonal resource variations
- Lower Cost of Energy
  - Resource diversity minimizes battery size and fuel use
- Higher "Quality" of Service (maybe 24 hour)
  - For productive uses/income generation during the day
- Existing Diesel & Distribution System Investment

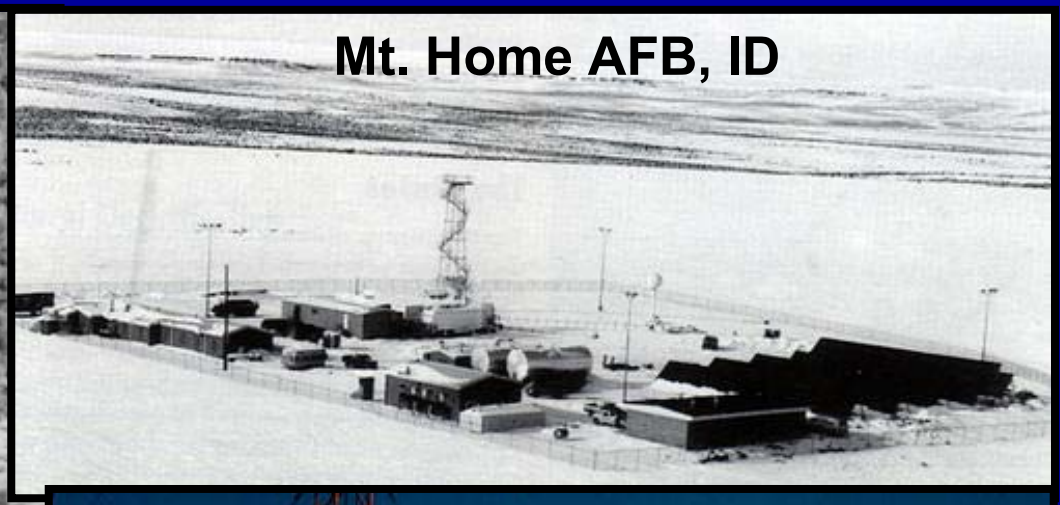
Renewable resources may complement each other



Lower cost of energy

- PV is easiest but expensive, so offsetting PV capacity with additional wind capacity or diesel backup can reduce cost
  - PV costs approx. $4-5/W
  - Wind turbines cost approx. $1-2/W
  - Diesel generators cost approx. $0.5-0.9/W
- Batteries are expensive and easily damaged, so diesel backup can provide reliability and reduce cost
- Fuel can be expensive in remote areas, so limiting diesel run time can reduce cost

Hybrid Power System Examples: "Communications"



International Experiences

- There is already much experience with village power systems in China and around the world.
- Many of these have failed.
- The key reasons for failure are often institutional and not technical.
- It is most important to design the village power program with key sustainability issues in mind.

Lessons Learned
Xcalac, Mexico

Now Running on Diesel Only

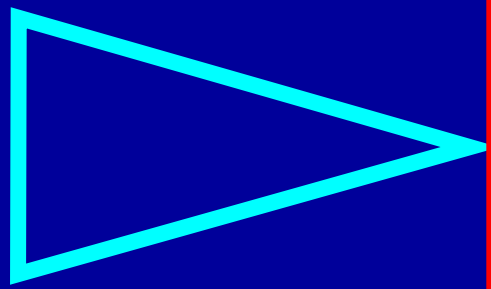
60 kW Wind, 12 kW PV, 40 kW Inverter

International experiences and lessons learned

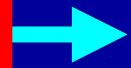
- Maintenance and repair
  - A maintenance support infrastructure must be established and nurtured from the very beginning of a project.
  - Repairing equipment in remote locations is difficult and expensive. In pilot projects, robustness and reliability are more important than energy conversion efficiency.
- Hybrid systems
  - The industry is sparse and immature -- resulting in high prices, costly implementation and support, and rapidly evolving designs.
  - Electronic controls and converters are the least robust component, therefore development of an electronic service capacity is important.
  - It is often more economical to install a new, appropriately sized diesel than to use the existing, oversized, poorly maintained one.
- Sustainability and replication
  - The transition from the pilot phase to commercial replication can be difficult. The more the pilot project can be set up to look and act like a business, the easier the transition.
  - Single projects in remote locations are not sustainable. Multiple systems in a region are required to develop and sustain the necessary support infrastructure.

Lessons Learned - Keys to Commercial Success

Technology
- 25 years of research
- manufacturing expansion



In-Country
Marketing
Distribution
Sales/Financing
Service
Maintenance
Revenue collection
INFRASTRUCTURE



Billions Cost-Effective Applications

Financing
-IFC
-Solar Development Group
-World Bank loans
- UNDP development assistance
- GEF environmental buy-downs
-Bilateral donors and banks
-Foundations
- Private Investors
- Country $$

Joint Ventures

Integrated Applications
Products

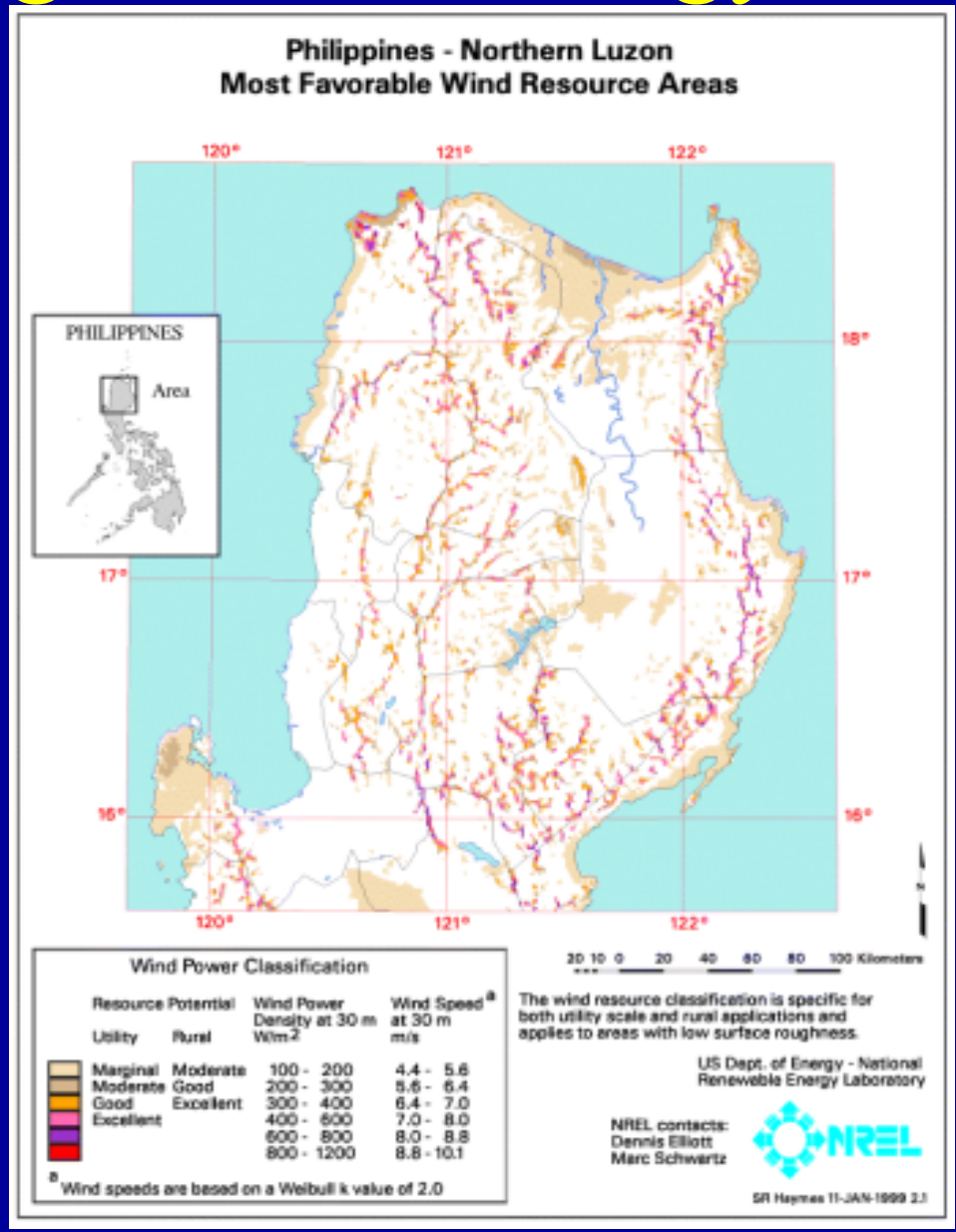
Training
Standards

A large enough quantity of equipment, in a small enough area, to reach the cash flow needed for local business viability.

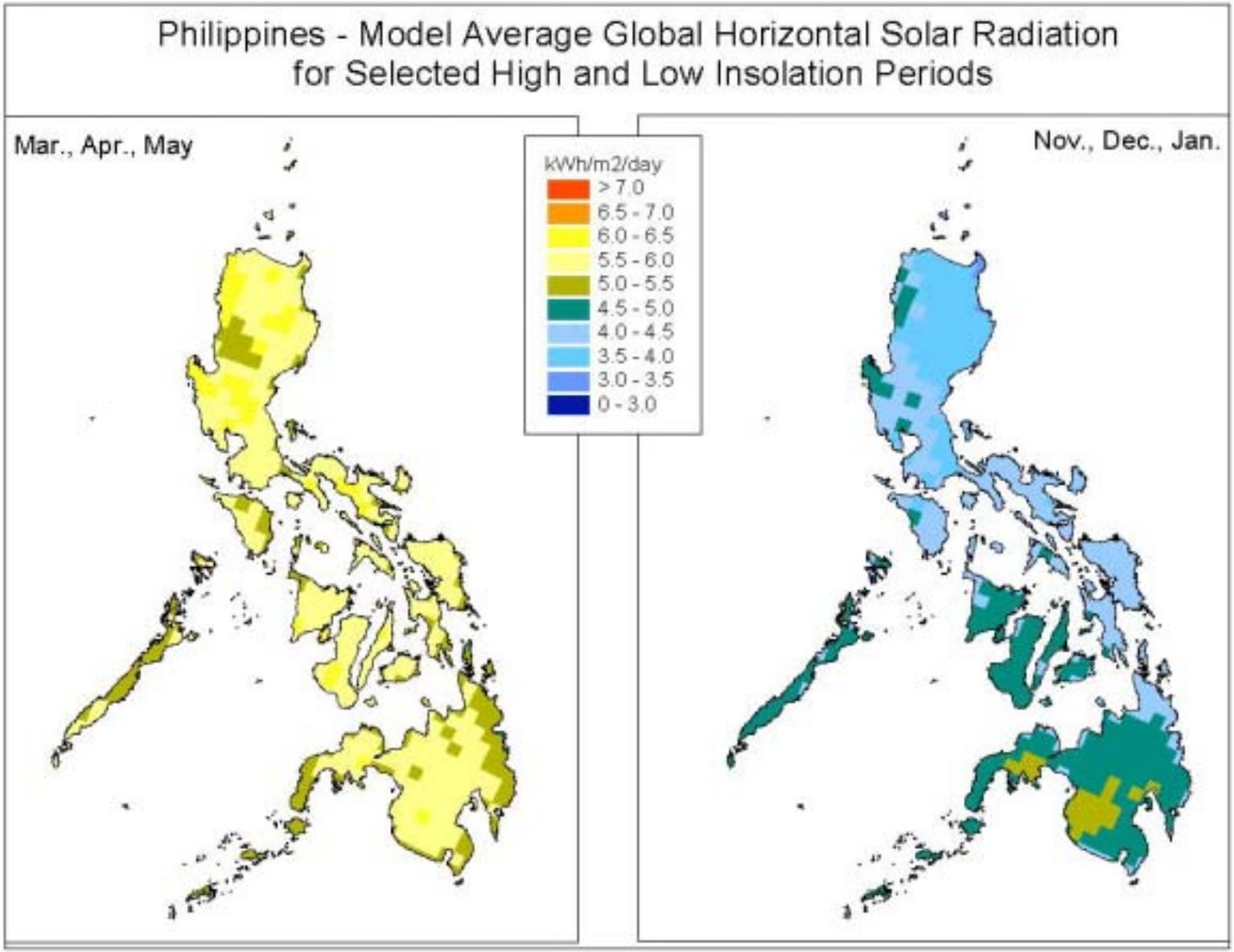
System Design and Options Analysis

System Design Methodology

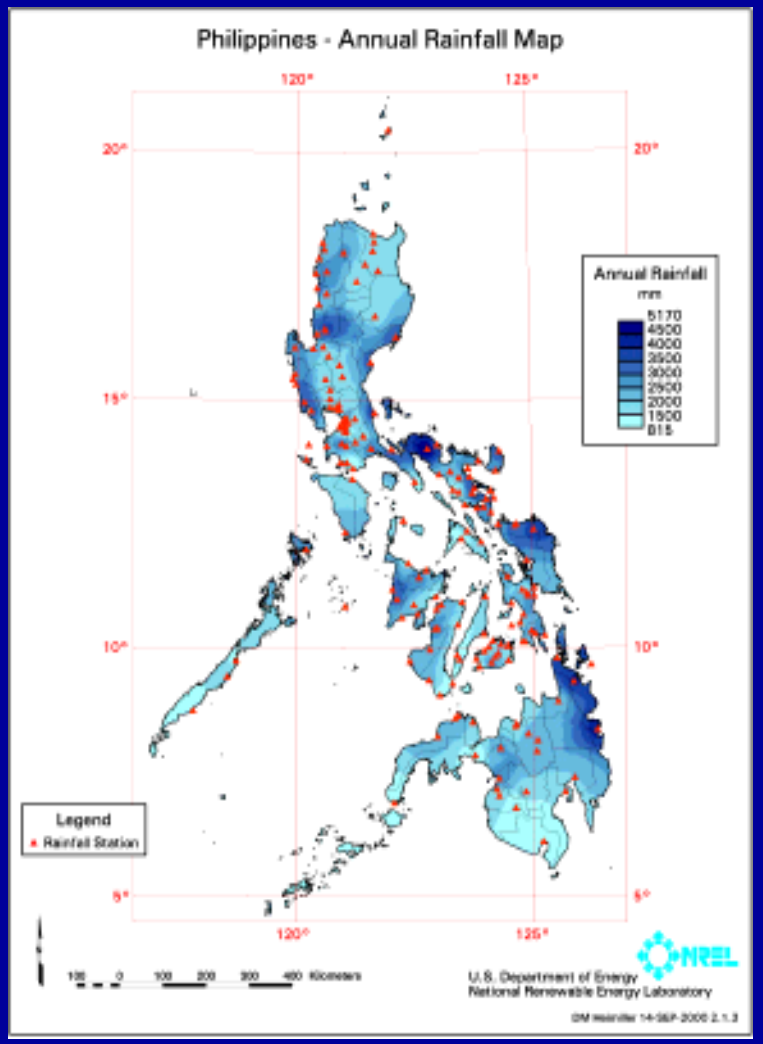
- Resource assessment is critical
  - Wind data from meteorological stations is often inaccurate
  - Power output from wind turbine is very sensitive to wind speed: 6 m/s wind will produce 72% more power than 5 m/s wind. This can result in significantly lower cost.

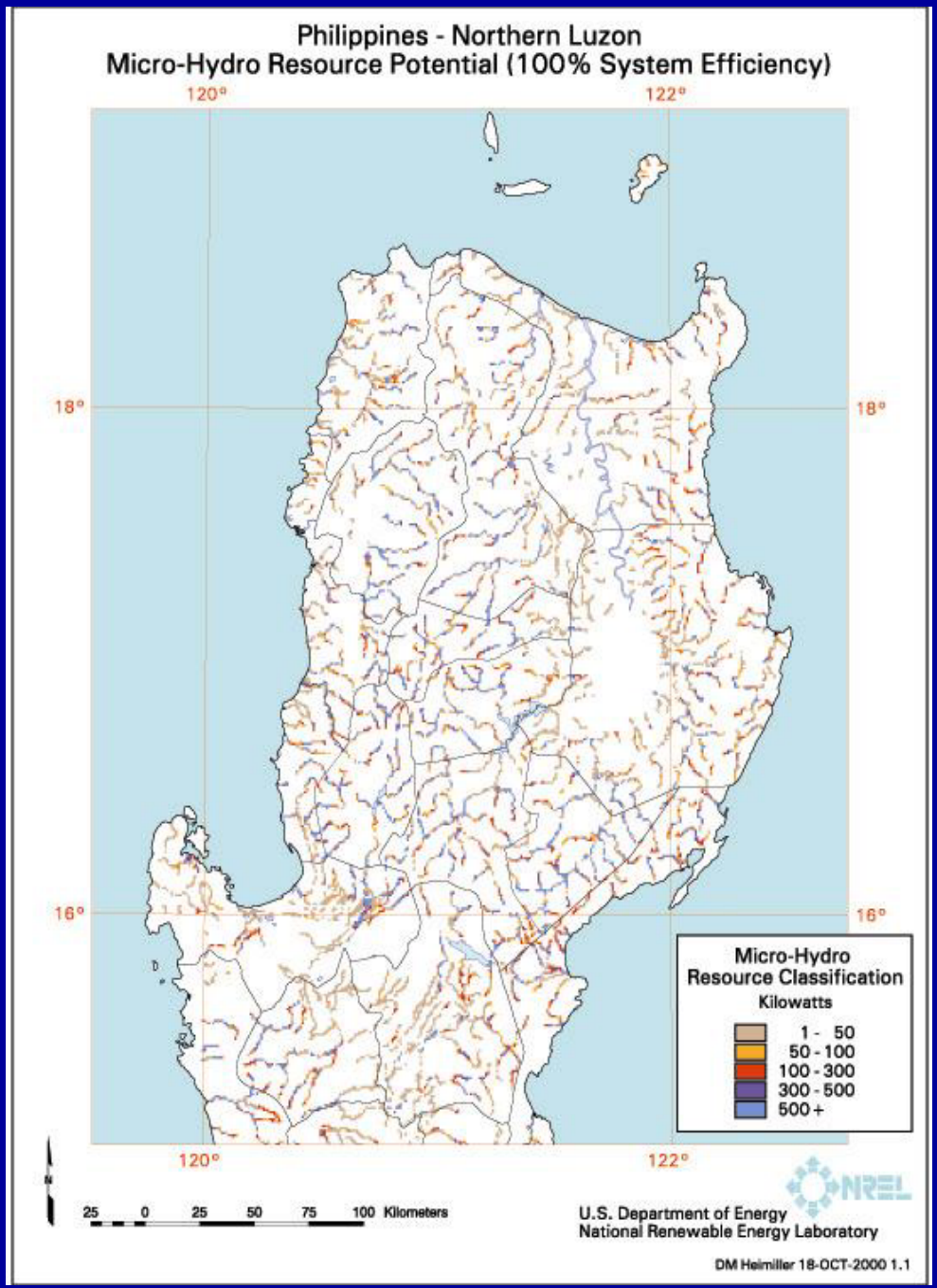


Renewable Resource Options: Solar

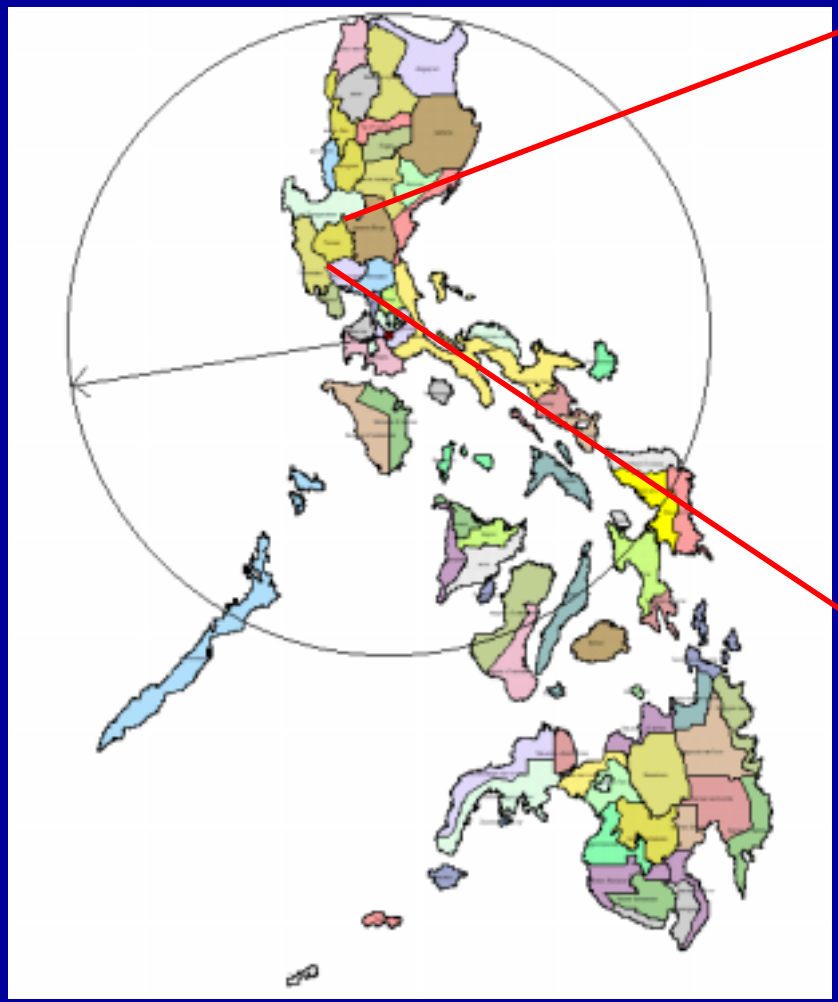


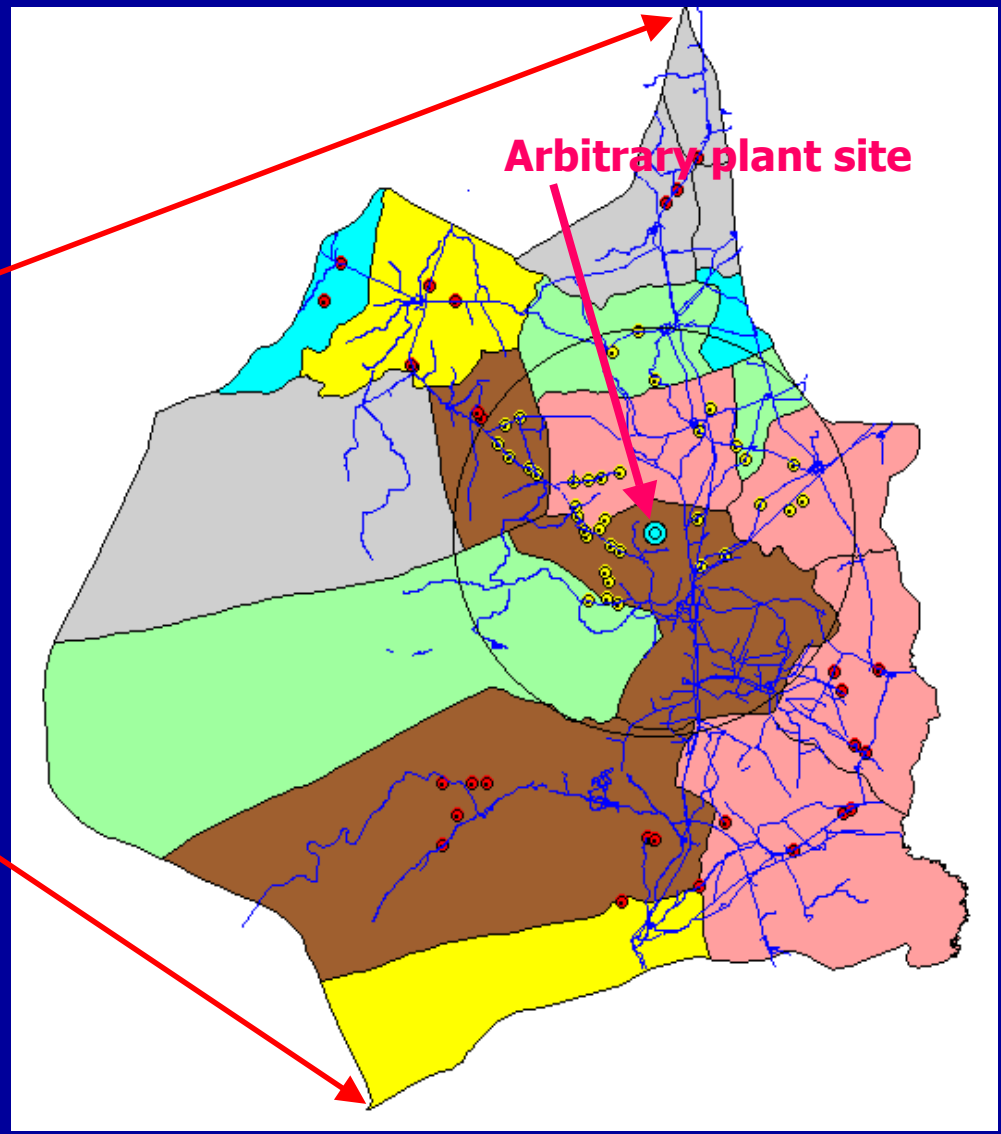
Renewable Resource Options: Hydro





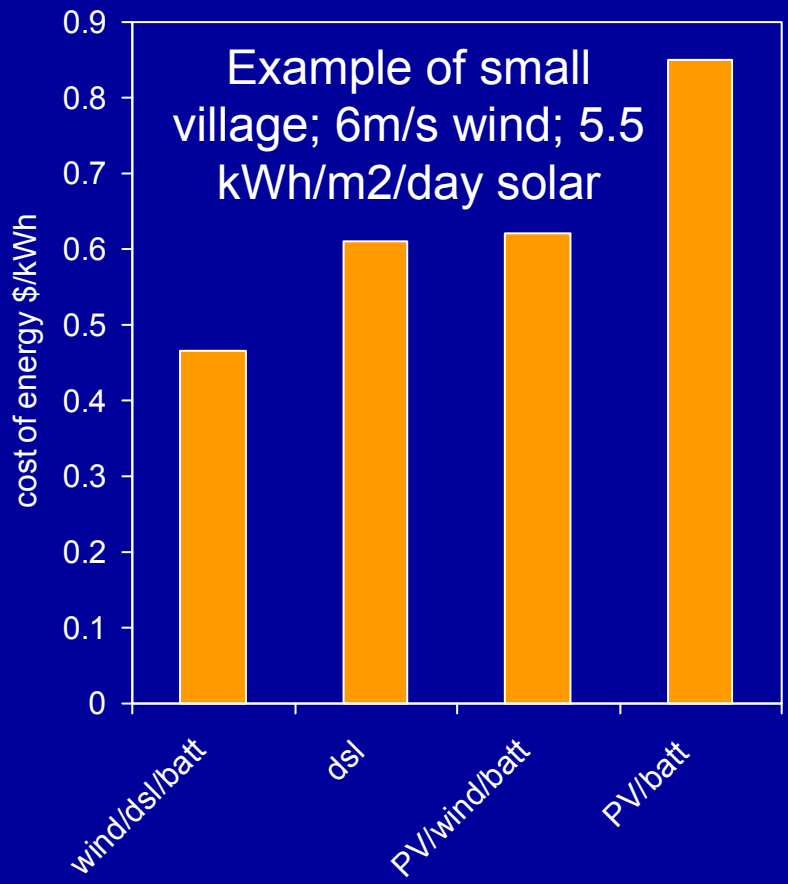
Renewable Resource Options: Biomass



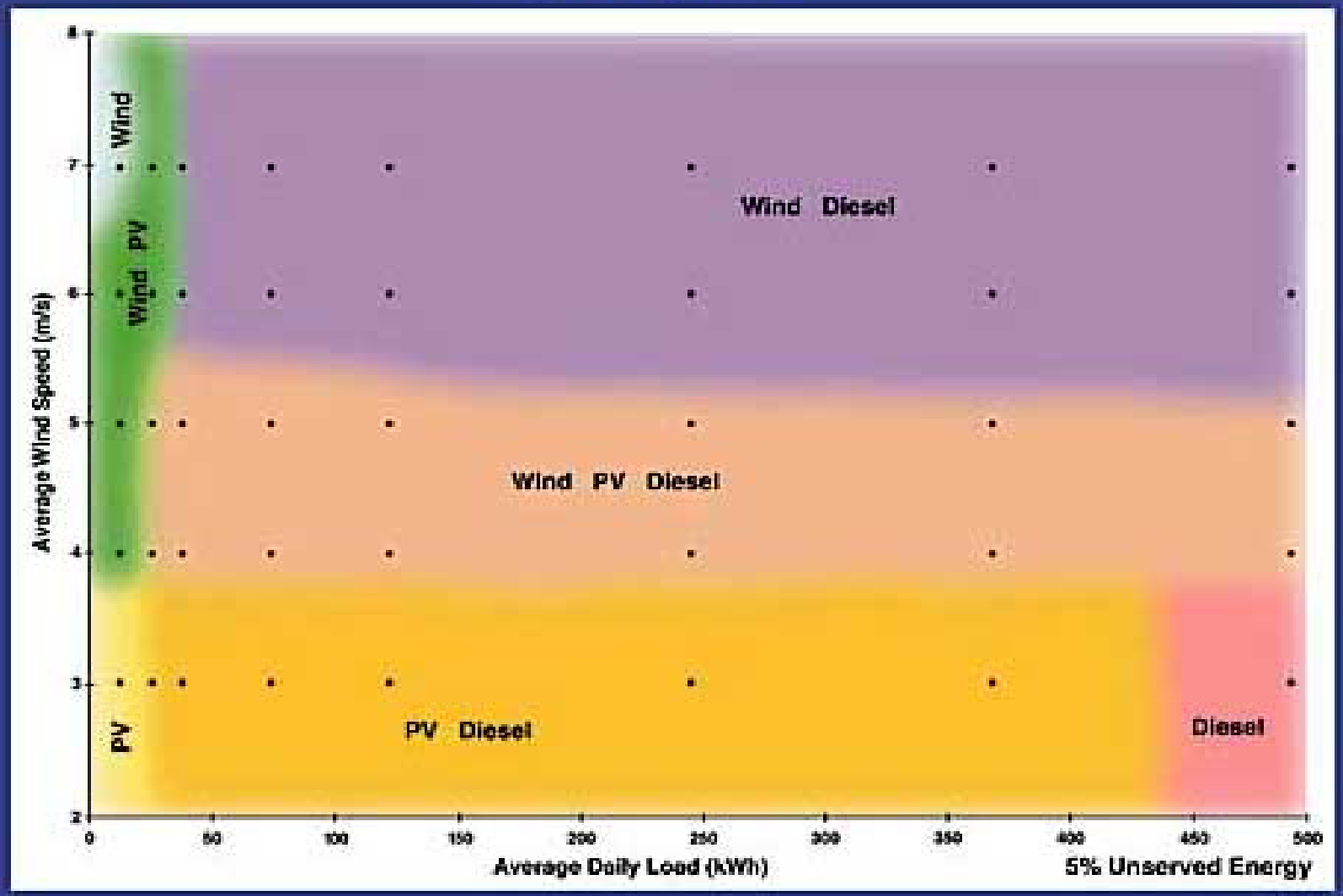


Options Analysis is critical

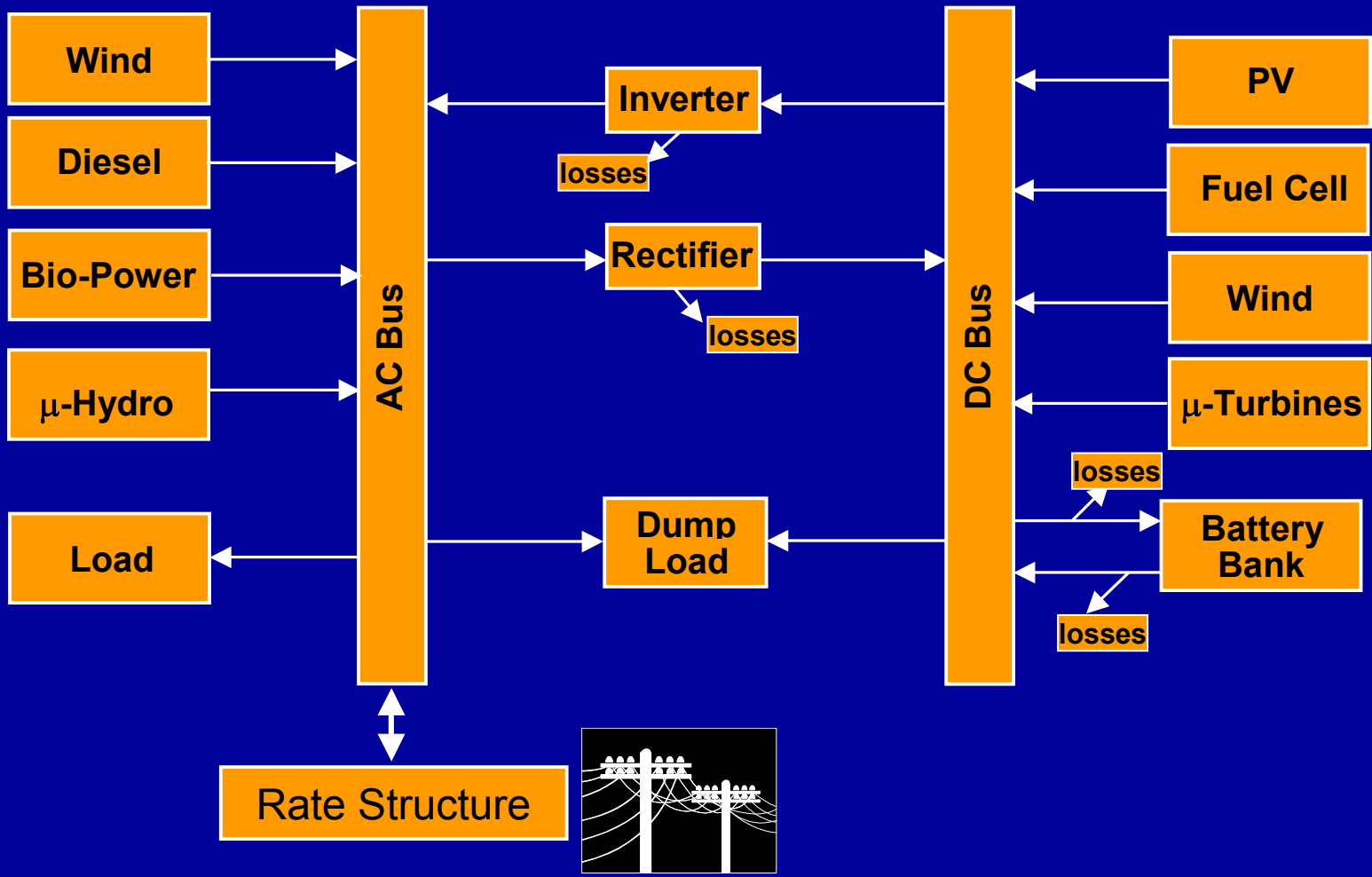
- Least-cost solutions – would a hybrid system or diesel backup help reduce the cost?
  - Batteries are expensive to replace and easily damaged
  - PV is expensive
- What are costs of maintenance, repair, fuel, replacement?
- Is there significant excess energy?



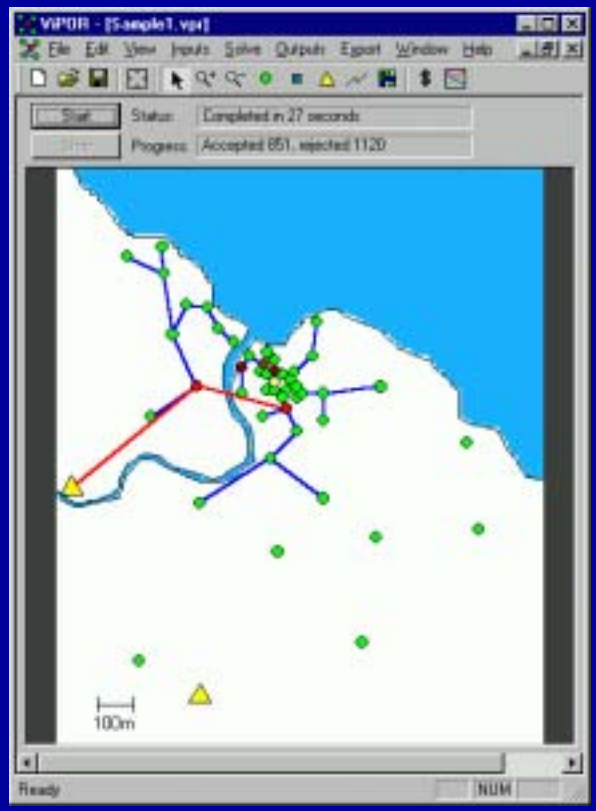
HOMER software model: Options Analysis

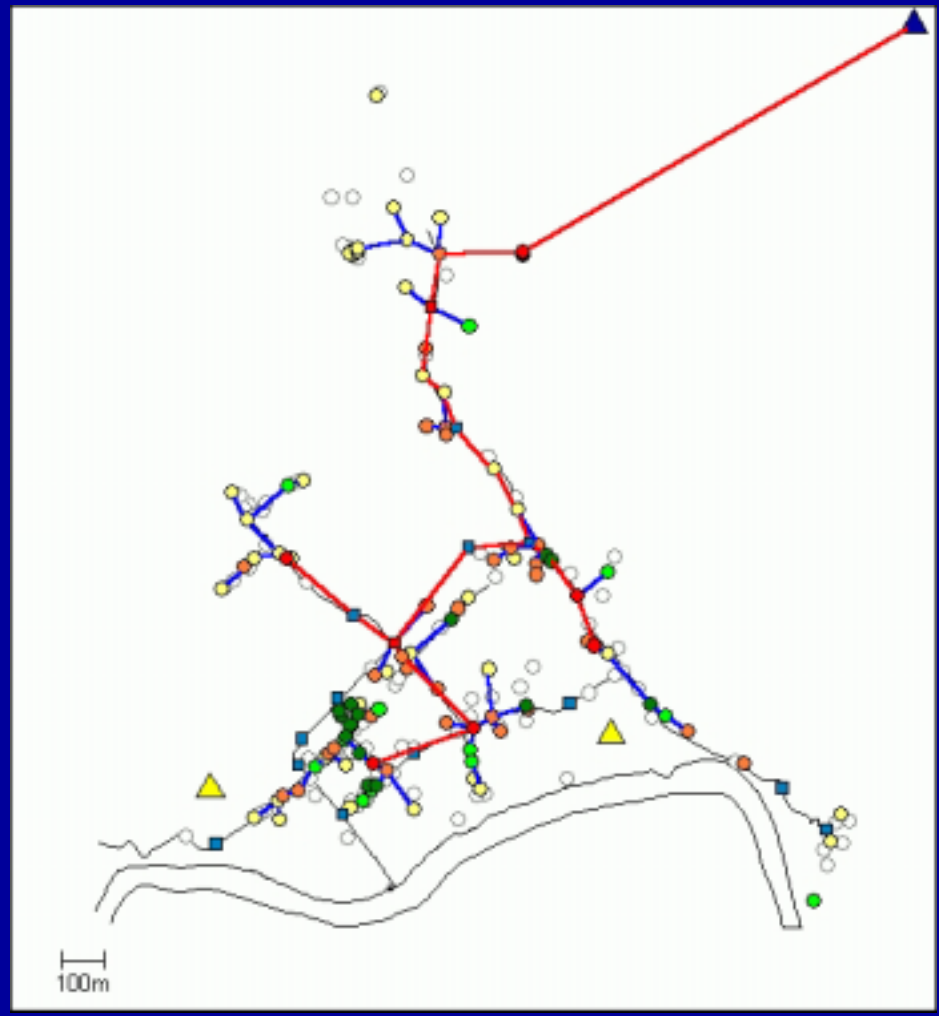


Village Power Hybrids
Hybrid2 and HOMER Models



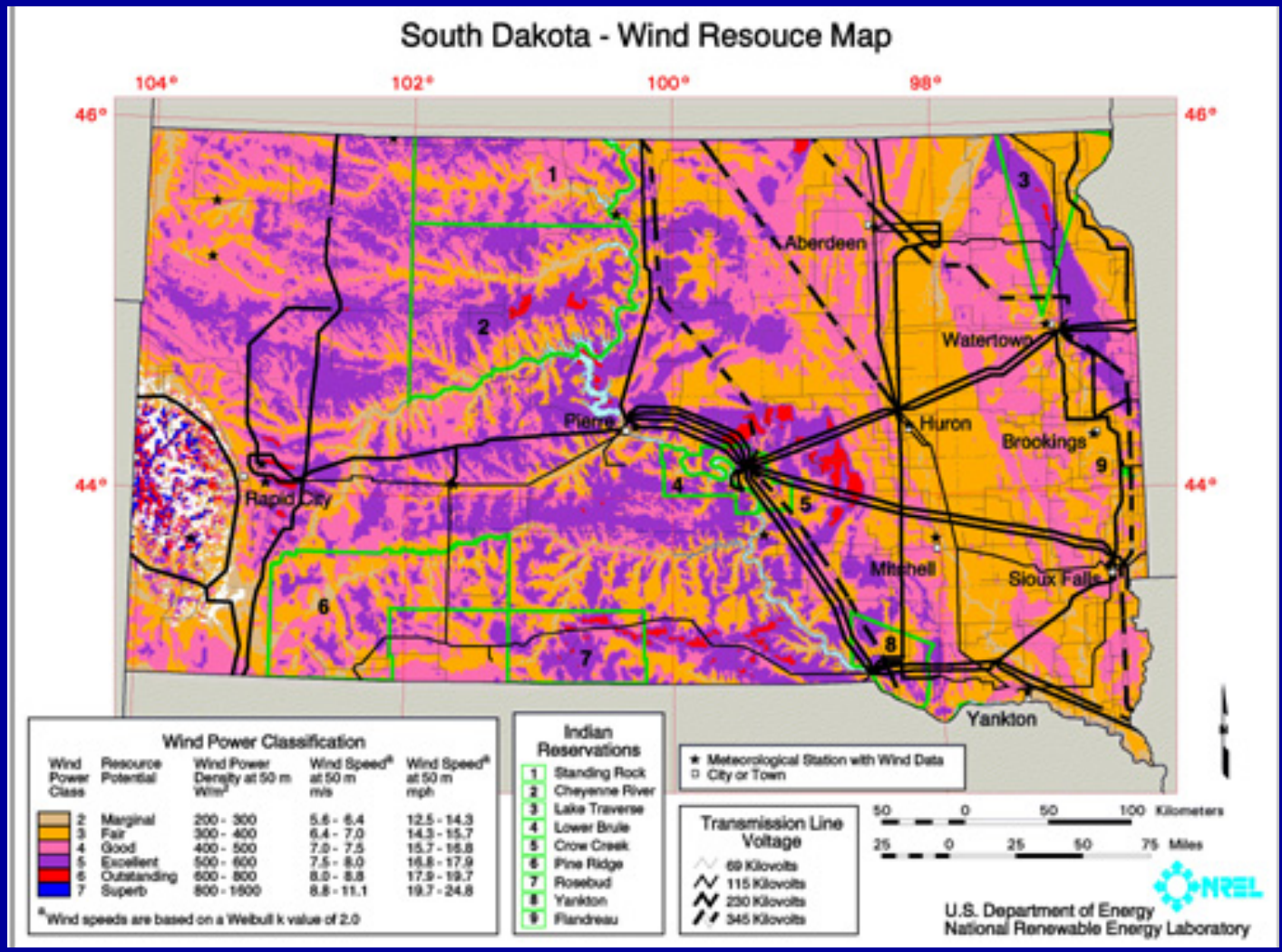
VIPOR model for distribution system





Stand-alone, village, or grid extension?

Integration of Resource, T&D, and Technology Options Analysis



Automated siting knowing resource availability, T&D investments and constraints

Tariffs and load management

Village systems often fail because of tariff and load management issues

- Xcalac, Mexico hybrid system – no tariffs, overloaded with refrigerators
- PV village systems in Gansu and Tibet – villagers did not obey instructions to limit use
- Micro-hydro systems in Thailand with meters – during peak hours, power systems crash from overuse
  - In this case, circuit breakers that limit power consumption at any one time would be better for load management
  - This would limit each household to a fixed amount of power so that the system does not crash during peak hours
- A village power system with incandescent lights or conventional refrigerators is a failure waiting to happen

Tariff structure have large impacts

- San Juanico, Mexico wind/PV/dsl system
- Tariff structure hindered commercial use of electricity
  - Residential charge was 27 RMB + 1.3 RMB/kWh
  - Commercial charge was 46 RMB + 2.2 RMB/kWh
- Lack of financing for efficient appliances, so some restaurants could not afford to use refrigerators
- Lack of information about efficiency, so villagers bought inefficient appliances

Tariff Structures

- Should be based on technology used
- The value of the first increment of power is *much* greater than the cost.
- Can use a two-part tariff
  - For low demand users, small RMB/kWh charge
  - For high demand users, larger RMB/kWh charge
  - This ensures most of subsidy goes to the poor
  - This encourages energy efficiency
  - This helps recover costs for system O&M and also system expansion in the future
- Can ration use with circuit breakers
- Prepay meters
  - Eliminate collection risk
  - Simplify administration
  - Most commodities are purchased in this way

Productive Uses/Income Generation

How can renewable energy help alleviate poverty in rural areas?

- Rural electrification programs use renewable energy mostly to provide social welfare benefits such as lighting for education or television for entertainment, etc.
- That's good but not enough.
- And in many cases, these systems only add to the debt burden of end-users and do not increase economic development.

Microenterprise Productive Uses Income Generation

- Small businesses, or microenterprises, can benefit from access to even small amounts of electricity such as the output of a solar home system:
  - Extended operating hours
  - Attract customers
  - Communications
  - Education
  - Improved working conditions

- Larger amounts of electricity, such as AC power from hybrid systems, can power additional productive uses:
  - Mechanization/automation – mills, drills, pumps, etc.
  - Preserve products – refrigeration, ice, etc.

Electricity by itself does not increase economic development!

- Enabling conditions include:
  - Reliable and affordable electricity
  - Availability of tools and machines for productive applications
  - Financing for applications/tools/machines and working capital
  - Capacity building both for technical and business challenges
  - Market for increased quality and production

PV Electronic Repair Shop

- Repair of TV, radio, cassette player, lights, etc.
- 34W PV solar system
  - 2 x 7W lamps
  - 1 DC soldering iron
  - 2900 RMB
  - 25% down; 75% over next 2 yrs at 8% interest rate
- Use of lamps 4hrs/day; use of soldering iron 6 hrs/day
- Benefits:
  - Increased income with electric soldering iron
  - Extended hours of shop
  - Increased income of 200 RMB/day
  - Better working environment

Global Village Energy Partnership

Village Power Program

- Website
- Online project database with 140 projects from 30 countries
- Renewable energy guidebooks
  - Microenterprise
  - Rural health clinics
  - Rural Schools
- Newsletters
- Village Power Conferences

Global Village Energy Partnership

- Aims to reduce poverty and enhance economic & social development for millions around the world
- Objectives:
  - Catalyze country commitments to energy-poverty reduction
  - Bridge the gap between investors, suppliers & users
  - Facilitate policy and regulatory frameworks for scale-up
  - Serve as a marketplace for lessons learned, best practices
  - Create and maintain effective coordination mechanisms
- 10 Year Partner Based Program:
  - Significant number of countries with energy-poverty reduction programs
  - >400 M people unserved with energy access
  - >50,000 new communities served
  - Cadre of trained entrepreneurs
  - Increases in productivity, income, environment, quality of life

GVEP Products and Services

Action Plans	Political Commitment Policy Framework Multi-sector Demand Assessment
Capacity Development	Entrepreneurial Services Consumer Organization Support Cross Sector Linkages
Financing Facilitation	Info on Funding Sources, Seed Capital Local Banker & Micro Credit Training Funding Mobilization and Access
Knowledge Management	Data Bases: Partners, TA sources, Best Practices, Lessons Learned, Dissemination: website, toolkits, radio Info Exchange: TA, workshops
Results and Impact Monitoring & Evaluation	Information on Contribution to Service Delivery for Health, Water, Schools, SMEs, Agriculture, Households

Contact information

- Debra Lew
  - Tel +1 303 384 7522; fax +1 303 384 7419
  - dlew@nrel.gov
- GVEP website:
  - http://www.gvep.org
- NREL Village Power website:
  - project database, 3 guidebooks, analytic tools
  - http://rsvp.nrel.gov
  - HOMER software can be downloaded free at:
  - http://analysis.nrel.gov/homer